TIP 258: Development of a State-of-the-Art Computational Framework and Platform for the Optimal Control of Multi-reservoir Systems under Uncertainty

Context

Much of the power that is produced from the Federal Columbia River Power System (FCRPS) is incidental to the water management activities required for other, multiple non-power uses and system objectives. A single objective function is not adequate to describe the goals of operating the FCRPS under these conditions. Further, it is a common occurrence that there is a significant difference between forecasted and actual streamflows. Most models lack of state-of-the-art strategies for handling flexibility (global and local), uncertainty, optimization of multiple objectives, visualization and high-performance computing. The proposed research, if successful, will greatly advance the capabilities of current models. Increased computational speed, acquired from parallel processing, advanced uncertainty and risk analysis and a robust algorithm are key.

Description

The state-of-the-art model to be developed will (1) handle uncertainty and risk analysis, (2) quantify operational flexibility, (3) visualize and display large amounts of complex data to support real-time and planning decisions, and (4) support parallel computing that fully utilizes the advanced capabilities of high performance clusters.

At the completion of the proposed research (two years), the resulting tool will be a parallelized hybrid computer model for the real-time operation and planning of multi-objective and multireservoir systems that accounts for uncertainty and flexibility. The resulting model could potentially replace the current tool used by BPA for short-term operation of the FCRPS and be used as the main computational engine for future real-time operation of this system under different streamflow and load scenarios.

The computer model to be developed will produce simulation, optimization and visualization results in a small fraction of time compared to that produced using a single processor as is currently done at BPA. It will achieve stable and feasible results in high-resolution time steps and will account for uncertainty as well as global and local flexibility. Furthermore, the platform used for the model development will be MATLAB, which is under continuous development. It integrates computation, visualization, and programming in an easy-to-use environment. That makes this environment a suitable platform for easy integration with any current or future framework used by BPA, including power production and marketing.

Why It Matters

The primary contribution of the proposed research is the development of a novel framework for modeling uncertainty in complex systems, which can be exploited for efficient and robust, multi-objective optimization. Uncertainties play a major role in the operation of any system. In seeking to optimize a system, the natural question is – “How should the system be operated given the uncertainties affecting the system?” The computational burden of hydraulic routing models constitutes a severe limitation, even without considering uncertainty, because the implementation of a real-time operation strategy that combines simulation and optimization may require hundreds or even thousands of simulations for each operational decision. Thus, a faster, more flexible, user-friendly system is imperative to better model and control this increasingly complex river system. The computer model to be developed will greatly improve future real-time operation of the FCRPS under different streamflow and load scenarios.

Goals and Objectives

1. Robust and efficient multi-objective optimization: Determining and assembling in MATLAB the most robust and computationally efficient hybrid (combined genetic algorithm-local search method) and parallelizable approach (with no uncertainty yet).
2. Uncertainty: Developing an innovative uncertainty modeling and propagation framework.
3. Flexibility: Developing a flexibility framework and its implementation into the multi-objective optimization model.
4. Visualization: Assembling a state-of-the art and operator preferred visualization in MATLAB.
5. Integrating the developed model components: The resulting tool will be a parallelized hybrid model for the real-time operation and planning of multi-objective and multi-reservoir systems that accounts for uncertainty and flexibility.

TIP 258: Development of a State-of-the-Art Computational Framework and Platform for the Optimal Control of Multi-reservoir Systems under Uncertainty

Project Start Date: September 1, 2012

Project End Date: August 31, 2014

Funding

Total Project Cost:	$590,324
BPA Share:	$290,440
External Share:	$299,884
BPA FY2013 Budget:	$156,967

Reports & References (Optional)

Links (Optional)

For More Information Contact:

BPA Project Manager:
Denis Mai, dtmai@bpa.gov

Participating Organizations

Oregon State University